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A STUDY OF CHILDREN'S ERROR TENDENCIES DURING LEARNING.

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THE ERROR FACTORS WHICH OPERATE DURING THE DISCRIMINATION LEARNING OF NORMAL CHILDREN WERE STUDIED. THREE EXPERIMENTS WERE CONDUCTED TO COMPARE RESPONSE-SHIFT AND RESPONSE-PRESERVERATION TENDENCIES OF DIFFERENT AGE GROUPS. THE FIRST EXPERIMENT INCLUDED 4-, 6-, 8-, AND 10-YEAR-OLDS WHO WERE GIVEN REWARD AND NONREWARD PROBLEMS. THE SECOND EXPERIMENT INCLUDED 4- AND 3-YEAR-OLDS WHO WERE GIVEN EITHER 75 PERCENT REWARD AND 25 PERCENT NONREWARD PROBLEMS, OR THE REVERSE. THE THIRD EXPERIMENT INCLUDED 4-, 6-, 8-, AND 10-YEAR-OLDS WHO WERE GIVEN REWARD PROBLEMS ONLY. A LEARNING SET PROCEDURE OF TWO-TRIAL PROBLEMS AND MULTIDIMENSIONAL STIMULI WAS EMPLOYED IN THREE TREATMENTS. BOTH RESPONSE-SHIFT AND RESPONSE-PERSEVERATION TENDENCIES APPEAR TO BE IMPORTANT SOURCES OF ERROR IN CHILDREN'S DISCRIMINATION LEARNING. (RS)

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A Study of Children's Error Tendencies during Learning

Cooperative Research Project No. S - 201

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Problem

Much of educational methodology rests upon the assumption that children learn to persist in producing responses or in making choices which have been rewarded. The rewards may be material or, more often, in the form of verbal reinforcement or praise. Earlier Skinnerian animal experimentation with operant conditioning and behavior shaping has been extended to the field of human learning and detailed explorations of schedules of reinforcement have been undertaken and applied to programmed learning.

Less attention has been given to the role of reward in discrimination learning, where the subject (S) must make a choice between two or more alternatives. The assumption has often been made that a simple relationship exists between an organism's choice and the previous pattern of rewards given to the alternative choices.

A recent series of experiments with monkeys (Harlow, 1959) has consistently shown that various identifiable sources of error (error factors) operate during discrimination learning. During the course of learning a series of separate but related problems, "learning to learn" takes place, so that fewer errors are made. The various error factors diminish in strength, but at different rates. The error factors include response-perseveration, (failure to shift to a different choice after nonreward of a choice), and response-shift, (failure to continue to repeat a choice which has been rewarded).

Although there is a considerable body of research with monkeys as Ss, there has been relatively little research designed to study the error factors which operate during the discrimination learning of normal children. What evidence there is points to the fact that

both response-perseveration and response-shift are important sources of errors in children's discrimination learning, and that the strength of the response-shift error tendency, in particular, changes with age.

The present research was designed to assess the strength of response-shift and response-perseveration error tendencies during the learning processes of normal children and to relate the strength of the two error tendencies to age and to experience with reward. A series of two-trial problems were presented to 4, 6, 8, and 10 year olds in a learning set procedure. New stimuli were used for each problem. Experience with reward and nonreward was varied by either rewarding or not rewarding S's choice on trial 1 of each problem according to a predetermined order. Thus, some groups could be given more problems with reward of stimulus choice on trial 1 and fewer problems with nonreward of trial 1 choice. The Ss were required to respond according to a win-stay, lose-shift principle. That is, on reward problems the stimulus choice was rewarded on trial 1 and choice of the same stimulus was rewarded on trial 2. Choice of the alternative stimulus on trial 2 was not rewarded. On nonreward problems the stimulus choice on trial 1 was not rewarded and S was rewarded for choice of the alternative stimulus on trial 2. Trial 2 errors could be categorized as of two types: on reward (win-stay) problems errors were of the response-shift type. Response-perseveration errors occurred on trial 2 of nonreward (lose-shift) problems.

Three experiments were conducted, each of which compared response-shift and response-perseveration tendencies of different age groups. In the first experiment 4, 6, 8, and 10 year olds were given an equal number of reward and nonreward problems and the strength

of response-shift and response-perseveration error tendencies was compared during the course of learning and for each age group. In the second experiment 4 year olds and 8 year olds were given either 75 percent reward and 25 percent nonreward problems or 75 percent nonreward and 25 percent reward problems. Strength of the two types of error tendencies was related to age and to amount of experience with reward and with nonreward. In the third experiment Ss, ages 4, 6, 8, and 10, were given reward problems only. Two types of procedures were used and a comparison was made between the strength of response-shift errors using both procedures. Half of the Ss in each age group were given reward problems with a procedure identical to that used for the presentation of reward problems in the first two experiments. That is, one object was presented on trial 1 and S was rewarded for displacing the stimulus. It was again presented, and its choice rewarded on trial 2 paired with a new and nonrewarded object. Half of the Ss were presented with a choice between two stimuli on trial 1 and choice of either stimulus was rewarded. Both stimuli were again presented on trial 2 and S was rewarded for choice of the same stimulus chosen on trial 1. In the first procedure response-shift errors may be associated with response to novelty. In the second procedure response-shift errors may be associated with generalization of excitation from the rewarded object on trial 1 to the unchosen object which is present on trial 1.

Objectives and Hypotheses

Experiment 1

Subjects who were 4, 6, 8, and 10 years old were given 12 reward and 12 nonreward problems per day for 6 days. The following hypotheses were made:

1. Subjects of all ages will make more response-shift errors than response-perseveration errors.
2. Initially, older Ss will make as many or more response-shift errors as younger Ss. However, older children will learn both the win-stay (reward) problem and the lose-shift (nonreward) problem more rapidly than younger children and will make fewer errors of both types. With age there will be a greater decrease in the number of response-shift errors than in the number of response-perseveration errors.
3. There will be more response-perseveration errors on non-reward problems which are presented following reward problems (different type problems) than on non-reward problems which follow other reward problems (same type problems). Similarly, there will be more response-shift errors on reward problems which follow nonreward problems than on reward problems which follow other reward problems.

Experiment 2

Subjects who were 4 and 8 years old were given 24 problems per day for 6 days. Each S was given both reward and nonreward problems but experience with reward and nonreward differed for each of two groups. Half of the Ss in each age group were presented with 18 reward

and 6 nonreward problems per day. The other half were presented with 6 reward and 18 nonreward problems per day. The hypotheses were:

1. Children will respond to the different degrees of experience with reward and nonreward as follows: Those Ss with more reward problems than nonreward problems per day will have more opportunity to learn to repeat a choice after reward and will make fewer response-shift errors and more perseveration errors than the remaining Ss. Those Ss with more nonreward problems than reward problems will have more opportunity to learn to shift choice after nonreward and will make fewer response-perseveration errors and more response-shift errors than the remaining Ss.
2. When the data from both groups are combined there will be more response-shift errors than response-perseveration errors.
3. More errors of both types will be made by younger children than by older children but there will be more of a difference between the number of response-shift errors made by older and younger Ss than in the number of response-perseveration errors.

Experiment 3

The 4, 6, 8, and 10 year old Ss in this experiment were given 108 reward problems and no nonreward problems. Half of the Ss were presented with one rewarded object on trial 1 and choice of the same stimulus was rewarded on trial 2 when it was presented with a new stimulus. The procedure is identical to that used in Experiments 1 and 2 for the presentation of reward problems. The performance of these Ss in the 4 and 8 year age groups on the 108 reward problems will be compared with the performance on the reward problems of those 4 and

8 year old Ss from Experiment 2 who were given 108 reward problems and 36 nonreward problems. All of these Ss had an equal opportunity to learn to choose the same stimulus (not to shift) after reward but the Ss in Experiment 2 were also given 36 nonreward problems. It was hypothesized that the Ss from Experiment 2 would make more response-shift errors because of interfering transfer from their experience with nonreward problems on which Ss were required to shift to the choice of the new object presented on trial 2.

Half the Ss in each age group were presented with two objects on trial 1 and choice of either stimulus was rewarded. Both stimuli were again presented on trial 2 and Ss were rewarded for choice of the same stimulus which was chosen and rewarded on trial 1. A comparison was made between the performance of both groups. Although differences in performance might be expected there was little basis to predict which group would make more response-shift errors. The tendency to respond to novel stimuli on trial 2 was expected to increase response-shift errors in the group which was presented with only one stimulus object on trial 1. In the group which was presented with two stimuli on trial 1 generalization of excitation from the rewarded stimulus on trial 1 to the stimulus which was not chosen was expected to increase response-shift errors.

Related Research

The problems in the present experiments may be classified as learning-set problems. Harlow (1959) describes learning-set as a particular type of transfer training between many problems of one class. In the present research the S is required to repeat a rewarded choice,

and to shift to an alternative choice after nonreward, regardless of the particular stimuli used for each of a series of two-trial problems.

The problem may also be described as a process of learning to suppress either or both of two particular error factors: response-shift and response-perseveration. Harlow (1950; 1959) has described error factors as reaction tendencies, or interactions among reaction tendencies leading to ordered but inappropriate responses to problems presented. Stimulus perseveration, the tendency to repeat a choice after nonreward, is related to stimulus preference, age, discrimination learning experience and adaptation. In learning-set experiments these errors are usually among the first to be inhibited. Response-shift, the tendency to shift to an alternative choice after reward, is described as the most persistent error factor. It occurs in animals with extensive discrimination learning experience, and Harlow believes that this error factor results from a tendency to explore a situation in terms of its incentive possibilities. Although there are many factors associated with learning difficulties in addition to these and other error factors, often much of learning can be described in terms of suppression of error factors. The extent to which this is so is, of course, dependent upon the experimental situation.

Much experimental work has been done with rhesus monkeys relating to response-shift errors in particular (Moss and Harlow, 1947; Riopelle, 1955; Riopelle and Francisco, 1955; Harlow and Hicks, 1957). However, most of the work with human Ss has been done with retardates (House and Zeaman, 1958; Ellis, et. al., 1962). Data for both the rhesus monkey and the human retardate rather consistently show that Ss make more errors on a two-stimulus discrimination problem if choice on trial 1

is rewarded than if trial 1 choice is not rewarded. This may be attributed to a tendency to approach the novel stimulus, or to response-shift, depending upon the experimental procedures used.

Blomquist (1957) investigated the relative strength of response-shift and response-persistence errors made by monkeys presented with a series of two-trial problems. One object was presented on trial 1, rewarded in half of the problems and not rewarded in the remaining problems. The object was again presented on trial 2 with a new stimulus object. Experiment 1 in the present report utilizes a procedure identical to Blomquist's, but with 4, 6, 8, and 10 year old children as Ss. Blomquist's monkeys made more correct choices on nonreward problems than on reward problems.

King and Harlow (1962) used the same procedure with three groups of monkeys given either 50 percent reward and 50 percent nonreward problems, 75 percent reward and 25 percent nonreward problems, or 25 percent reward and 75 percent nonreward problems. They conclude that "The efficiency with which the Ss utilized a particular trial 1 event (reward or nonreward) increases with the percentage of time that particular trial 1 event occurs." For the 50 percent reward group, and for all three reward groups combined, more correct trial 2 choices occurred on nonreward problems than reward problems. Experiments 1 and 2 in the present report partially replicate the King and Harlow experiment using normal children as Ss.

Two reports of work with normal children indicate that there may be an age difference in the strength of normal children's tendencies to shift choice after reward. Zerman and Graham presented one two-trial problem to normal preschool Ss. Two stimuli were presented on trial 1

and again on trial 2 following reward or nonreward of Ss trial 1 choice. Four year olds repeated a rewarded choice less frequently than 2 year olds, but the age difference was not significant. Stevenson and Weir (1962), using a three-choice problem, found that fewer errors were made by 3 year olds following a rewarded choice than following a nonrewarded choice. However, Ss who were ages 5, 7, and 9 years old made fewer errors following nonrewarded choices.

Experiment 1: Procedure

Subjects

The Ss were 32 Madison, Wisconsin children, 4, 6, 8, and 10 years old. Names were drawn from lists of children living in one of two housing projects administered by the University of Wisconsin for graduate students and faculty members and their families, and from registration lists of two nursery schools and of the summer playground program of an elementary school located near the two housing projects. The Ss were selected randomly with the following restrictions: They were limited to children of university graduate students and faculty or of parents with professional or managerial occupations. Eight Ss were selected from each of the following age ranges: 4 to 5 years, 6 to 7 years, 8 to 9 years, and 10 to 11 years. Two 4 year olds failed to complete the experimental task and they were replaced by other Ss: one child was reluctant to participate after three learning sessions and it was not possible to arrange appointments with the parents of another S after two sessions. Eighteen boys and 14 girls were distributed randomly among the four age groups. The mean ages of the groups were: 52 months, 78 months, 101 months, and 125 months.

Apparatus and stimuli

The apparatus was a simplified form of the Wisconsin General Test Apparatus (Harlow, 1959). Stimuli were 288 stereometric "junk objects" varying in many dimensions such as form, color, pattern, material, etc., and easily discriminable from one another. Two new objects were used as stimuli for each two-trial problem, with stimuli presented in different randomly selected pairs, and in a different random order for each S. Stimuli were presented on a 5 1/4 x 17 3/4 in. tray with three reward wells. The wells were 1 1/2 x 1 1/2 in. wide, 3/4 in. deep, and were 6 in. apart from center to center.

Procedure

Each S was tested on a series of 144 two-trial object discrimination problems of two types. On half the problems, reward problems, a single object was placed on trial 1 over the center well of the stimulus tray. The well contained a small toy or trinket. On trial 2 the same stimulus was presented covering a toy placed in one of the side wells. It was paired with a new stimulus object which covered the other empty side well. On the remaining problems, nonreward problems, the same procedure was followed, except that the stimulus which was presented on trial 1 covered an empty well, and when this object was presented again on trial 2 it covered an empty side well. It was paired on trial 2 with a new object which covered an outside well containing a toy. Trial 1 may be considered an information trial. On trial 2 S was required to utilize the information gained from trial 1 reward or nonreward and to respond according to a win-stay, lose-shift principle.

Each S was run individually in a separate room of the school or at his home. The child was seated at a table on which the stimulus tray was placed and the experimenter (E) baited the reward wells while the tray was screened from S's view. The child was given the following instructions on the first problem and on subsequent problems similar instructions were given:

Trial 1: "We are going to play a marble game where you can win some marbles. This (pointing to a cardboard box) is a bank where you can keep your marbles until we are finished." (The E puts up screen and places the first stimulus on the center well.) "See if that has a marble under it. Yes, it does, doesn't it?" (Or, "No, it doesn't, does it?")

Trial 2: (The E again screens the stimulus tray, fills the outer wells, and removes screen.) "One of these has a marble under it. Pick the one you think has the marble under it. Yes, the marble was under that one, wasn't it?" (Or, "No, the marble was not under that one, was it?") A noncorrection method was used.

Twelve reward problems and 12 nonreward problems were presented each day for 6 days or until S met a criterion of correct responses to 10 consecutive reward problems and correct responses to 10 consecutive nonreward problems. This is a particularly stringent criterion since the probability of meeting each criterion alone by chance is .05 (Grant, 1947). The probability of meeting both criteria by chance is .0025. Six experimental sessions were scheduled during a 2-week period, with two to four sessions per week. When S finished the 6 sessions or met criterion he was asked how he knew which object had a toy under it.

The presentation order of reward and nonreward problems and the right-left position of the correct trial-2 stimulus were the same for

all Ss and were identical on days 1 and 4, 2 and 5, and 3 and 6. The order of reward and nonreward problems was randomly determined with the restrictions that in each set of eight consecutive problems both problems should occur equally often, but neither problem should occur more than three times in succession. The right-left position of the rewarded trial-2 stimulus was also randomly determined but with the restrictions that in each set of eight consecutive problems the rewarded stimulus should be in the right and left position equally often, but not in the same position on more than two consecutive problems.

Marbles were used as rewards on day 1, and on subsequent days S was given a choice of rewards from an array of small toys and trinkets. Older Ss were allowed to exchange several marbles for larger toys after each experimental session if they wished to do so. The motivation level of children of all ages remained high throughout the experiment and at no point did Ss have to be urged to respond.

Experiment 1: analyses of the data and findings

Initial response tendencies and early learning

Figures 1 and 2 show for each age group the initial responses to the reward and nonreward problems, and the changes in performance during day 1. The data are presented in terms of mean percent correct responses on blocks of two consecutive reward or nonreward problems. From Figure 1 it can be seen that initially none of the groups tended to repeat a choice after reward. In fact, 6, 8, and 10 year olds tended to shift to the new object. Only the 4 year olds distributed their choices at a level which was close to chance. Although they showed initial response-shift tendencies following reward many of the 10 year olds quickly learned to suppress this error tendency and to follow a win-stay strategy. This was reflected in the sharp rise in

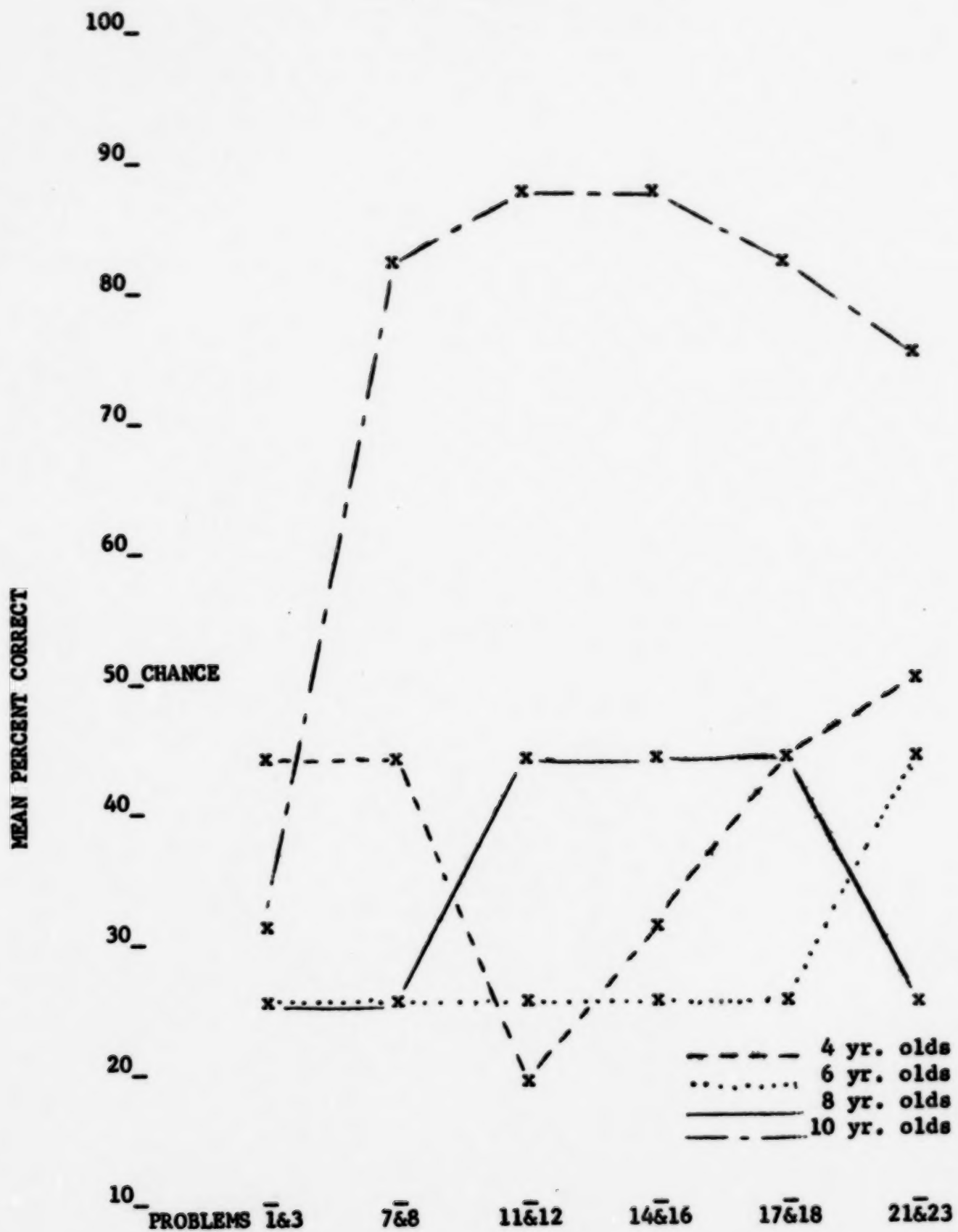


Figure 1. Trial 2 performance of 4, 6, 8, and 10 year olds on the 12 reward problems presented day 1.

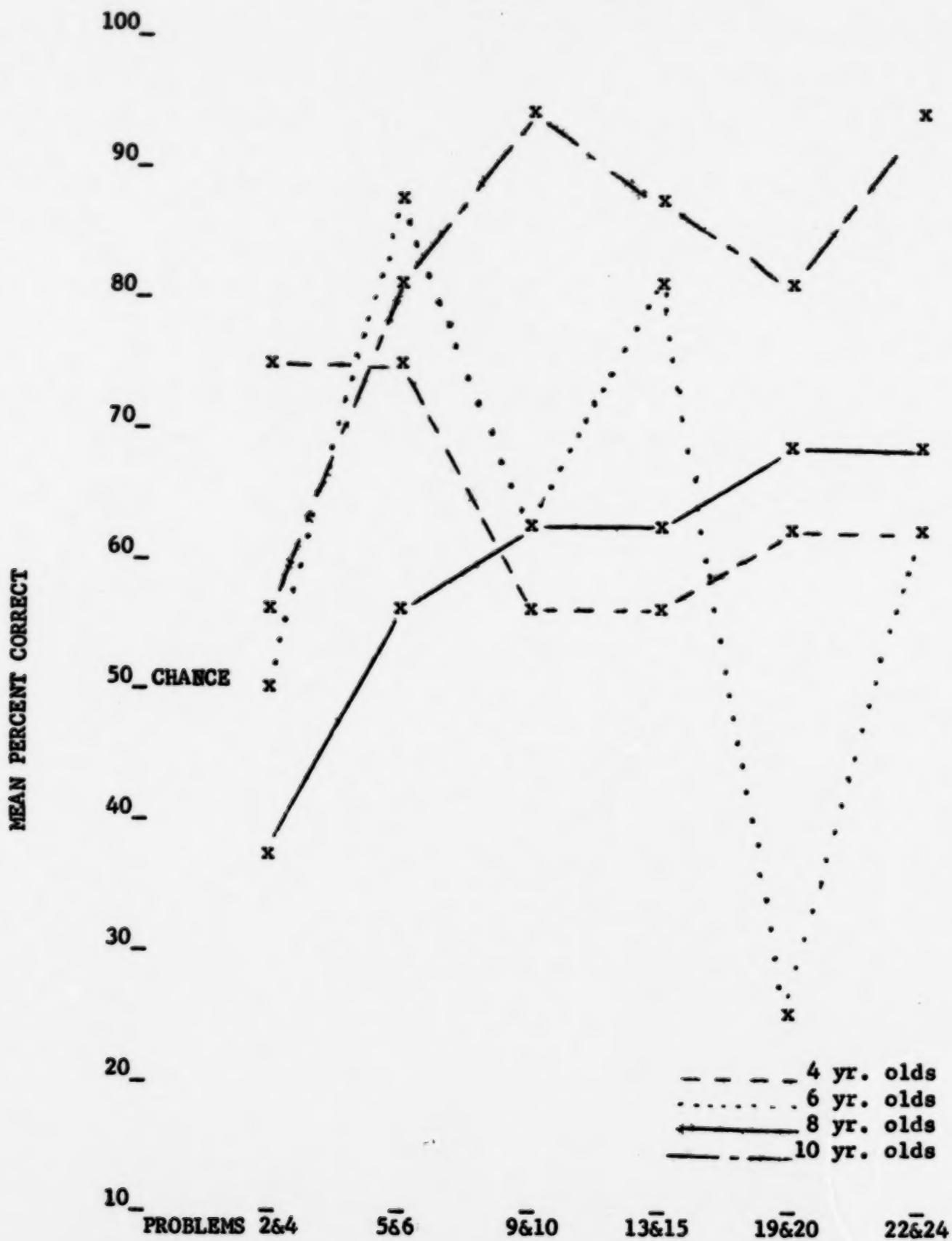


Figure 2 Trial 2 performance of 4, 6, 8, and 10 year olds on the 12 nonreward problems presented on day 1.

correct trial-2 choices after experience with the first two reward problems. None of the younger age groups showed evidence of learning the reward problem on the first day and their performance on the problem did not rise above a chance level during that learning session.

In contrast with the strong initial response-shift tendencies following reward, there appeared to be more variability of response following non-reward (Figure 2). Only the 4 year olds had an initially strong tendency to shift choice following nonreward. Other age groups responded at a level closer to chance, and the 8 year olds perseverated their nonrewarded choices more often than not. However, the 8 and 10 year olds showed a rather regular increase in correct responses to the nonreward problem on day 1 while the 4 and 6 year olds did not.

It should be noted that on the first four problems more of the older children tended to shift choice after reward than after nonreward. Only the 4 year olds shifted choice more often after nonreward than after reward. This was not true during the later part of the first learning session or during subsequent days. Four year olds made more response-shift and perseveration errors on later problems in the first session compared with initial problems; 8 and 10 year olds made fewer response-perseveration errors, and only the 10 year olds made fewer response-shift errors.

Learning during the six days

Figures 3, 4, and 5, and 6 show the daily performance of the four age groups. The data are presented in mean percent correct problem solutions of the reward and nonreward problems on each of the 6 days of learning. Table 1 presents an analysis of these data. There was a significant heterogeneity of the variance (Bartlett's Chi Square; error 1, 20.2, df 3, $p < .01$; error 2, 28.0, df 3, $p < .01$; error 3, 24.0, df 3, $p < .01$).

Heterogeneity was mainly due

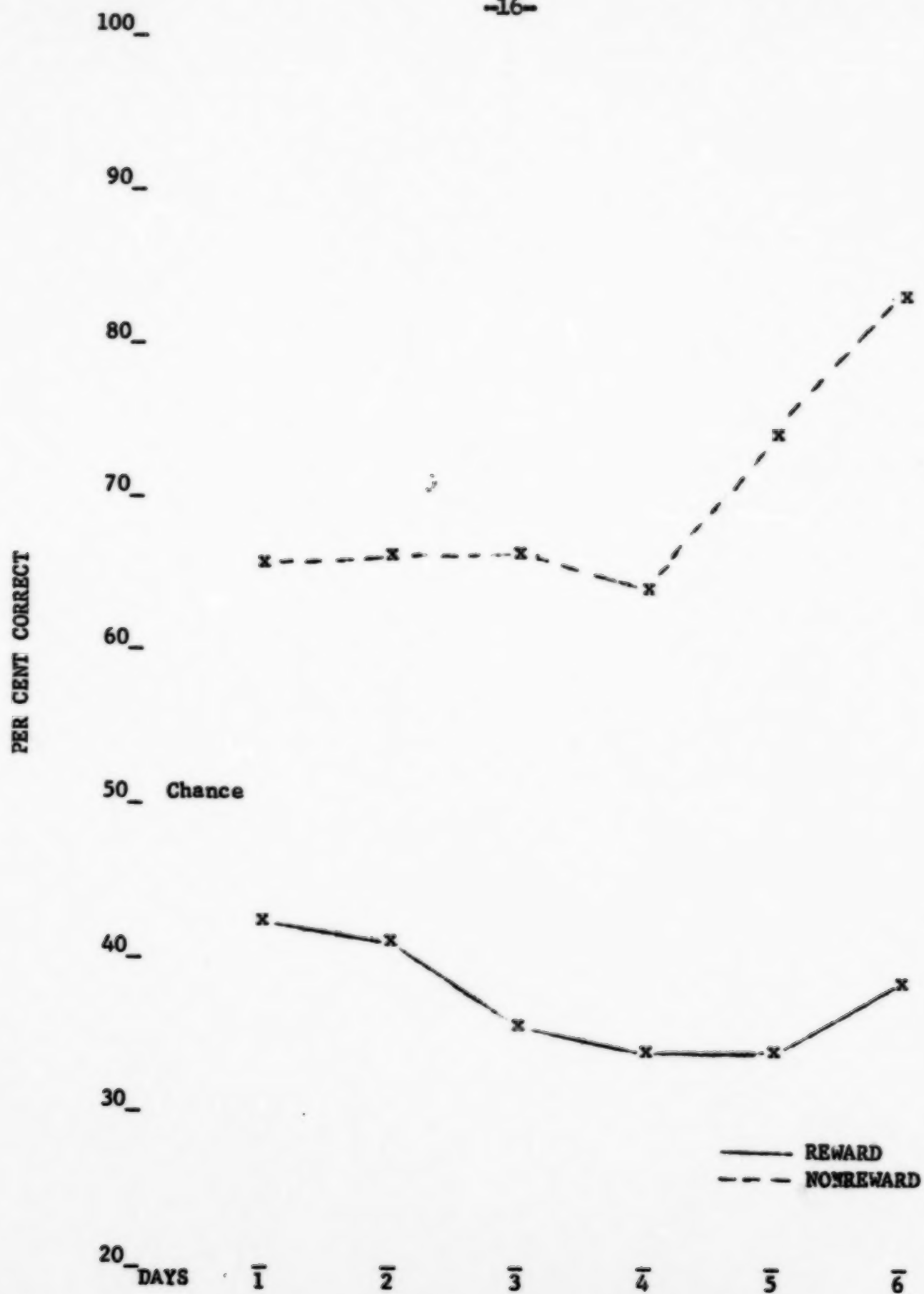


FIGURE 3. Trial performance of 4 year old subjects following Trial 1 reward and nonreward. Each subject was given 12 reward and 12 nonreward problems per day.

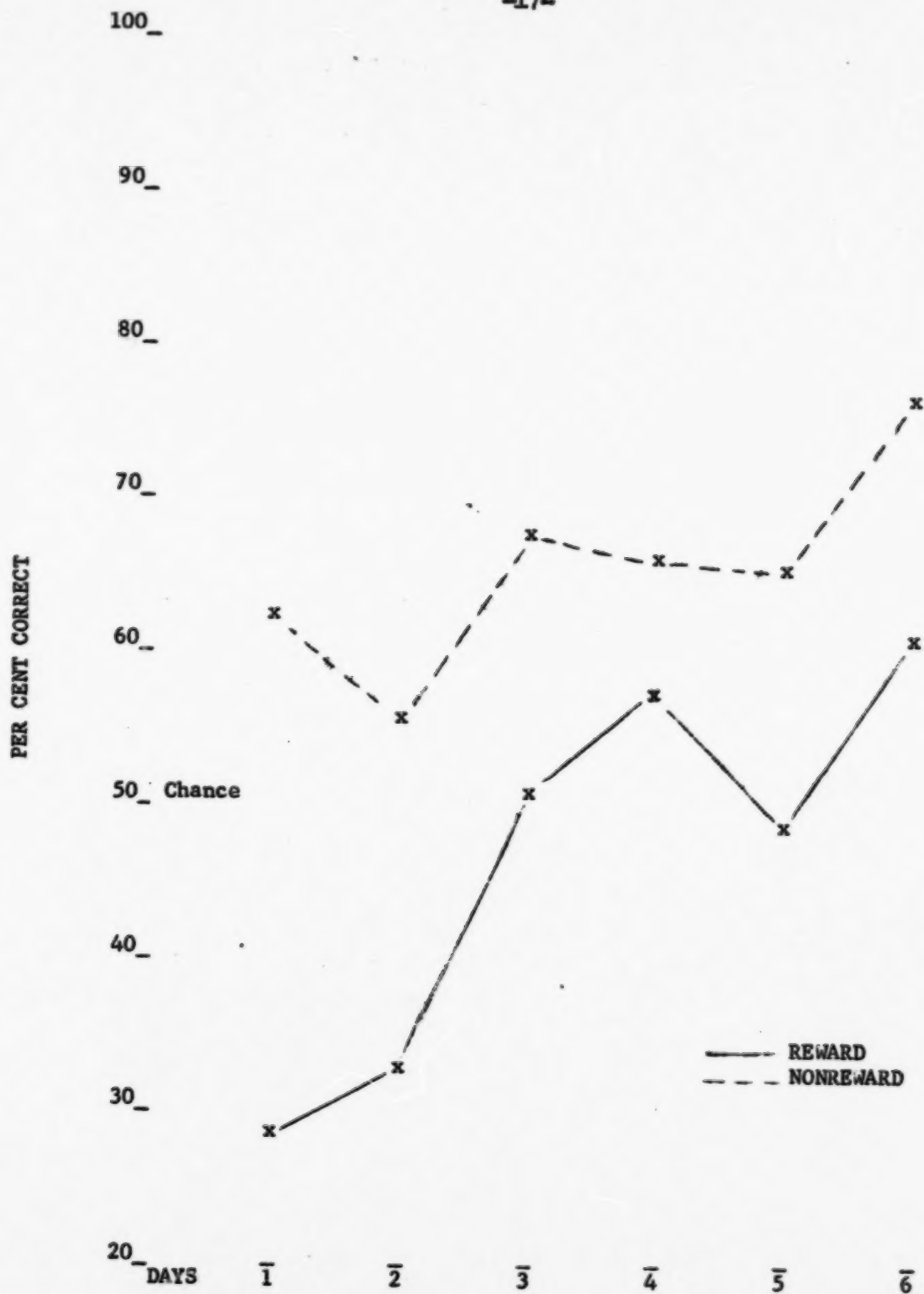


FIGURE 4. Trial 2 performance of 6 year old subjects following Trial 1 reward and nonreward. Each subject was given 12 reward and 12 nonreward problems per day.

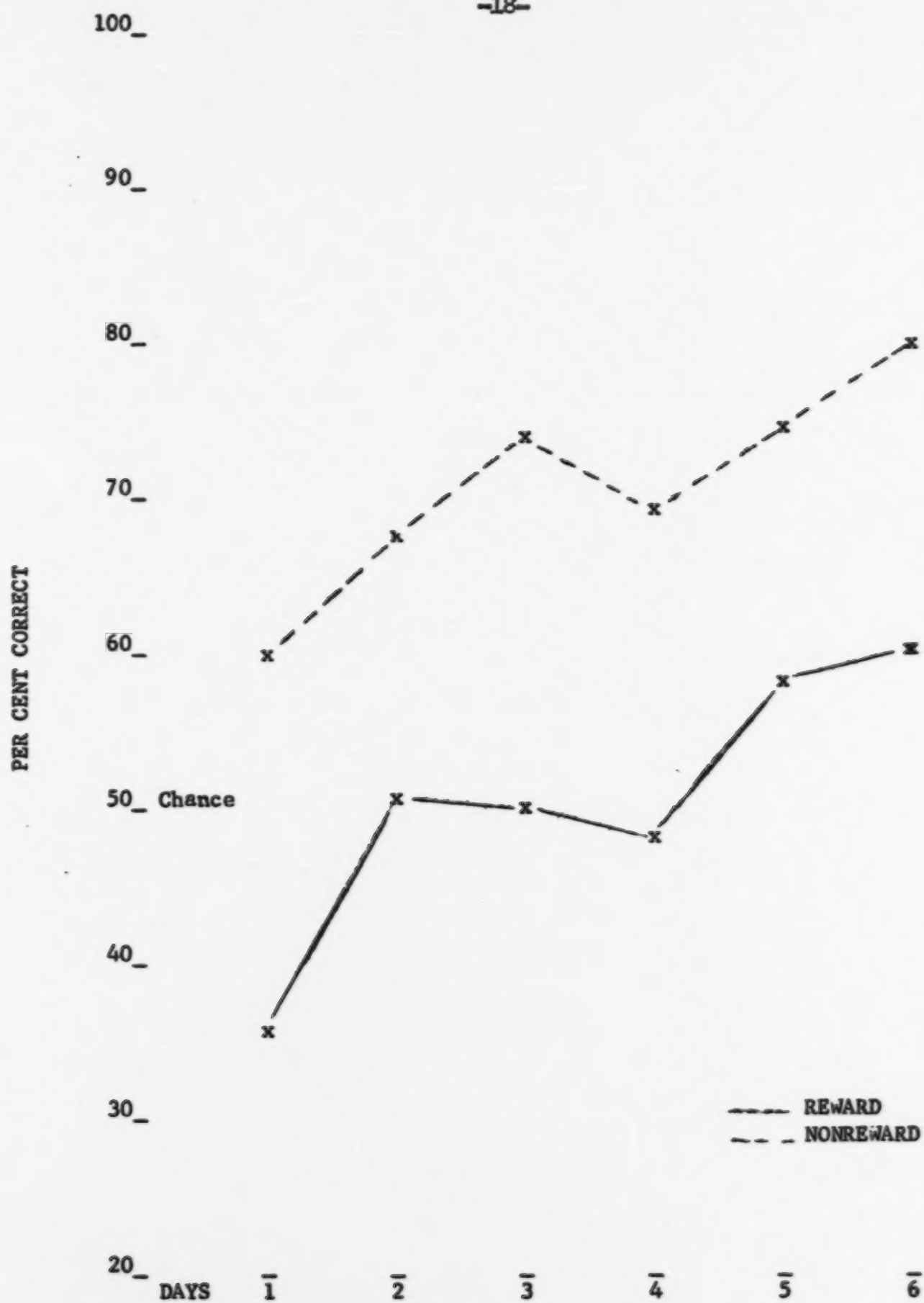


FIGURE 5. Trial 2 performance of 8 year old subjects following Trial 1 reward and nonreward. Each subject was given 12 reward and 12 nonreward problems per day.

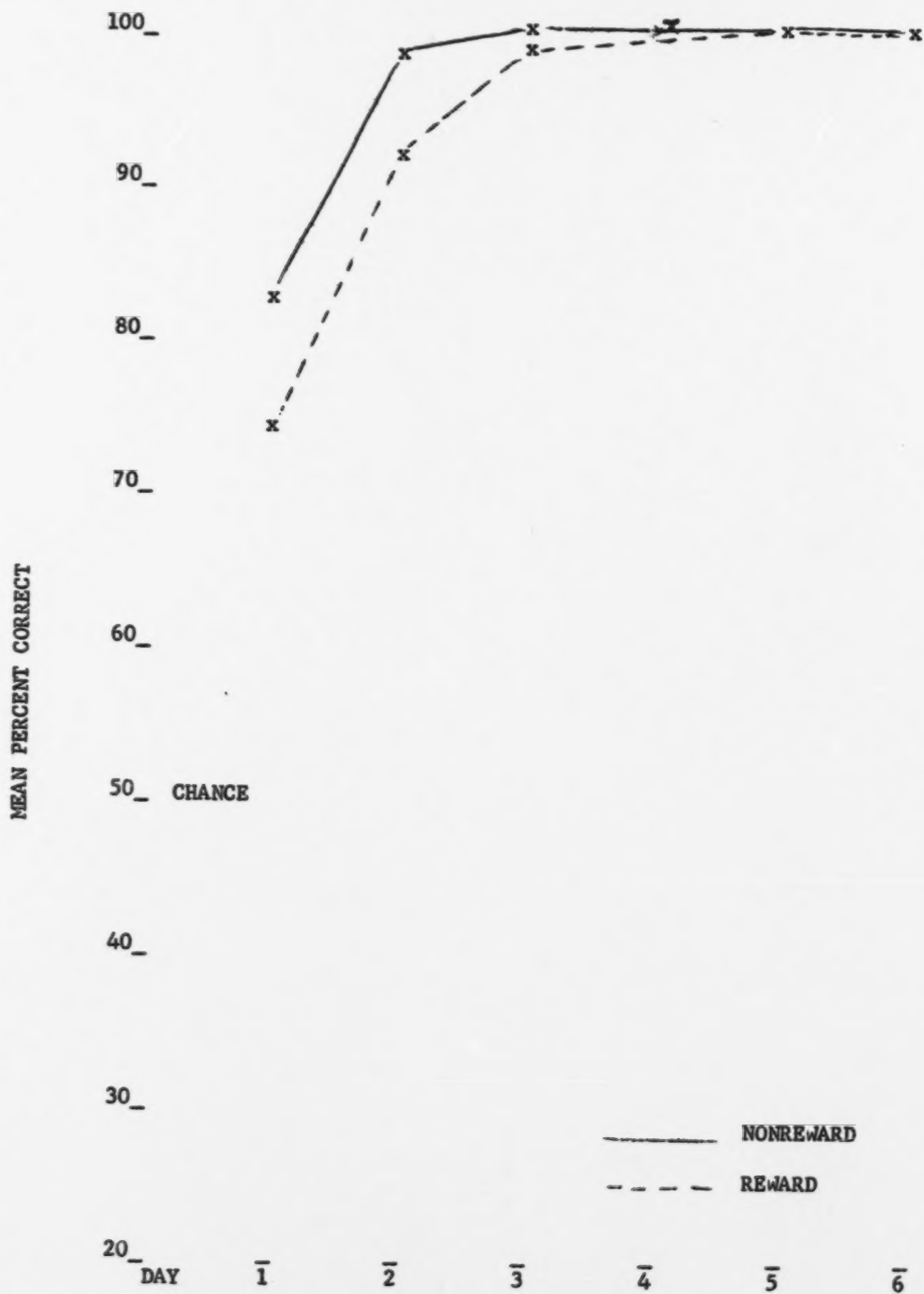


Figure 6. Trial 2 performance of 10 year old subjects following trial 1 reward and nonreward. Each subject was given 12 reward and 12 non-reward problems per day.

Table 1

Analysis of Variance of Learning Scores for Reward and Nonreward Problems

<u>Source</u>	<u>df</u>	<u>MS</u>	<u>F</u>
Between Ss			
Age (A)			
Linear	1	8,290,026.2	65.70 ^c
Quadratic	1	2,638,740.2	20.91 ^c
Residual	1	365,313.1	2.90
Error (b)	28	126,181.0	
Within Ss			
Problem (P)	1	3,343,200.2	26.61 ^c
Day (D)			
Linear	1	1,146,240.1	49.29 ^c
Residual	4	32,872.4	1.41
A x P			
Linear	1	940,312.5	7.49 ^b
Residual	2	69,545.5	< 1
A x D			
Linear	3	62,002.7	2.67 ^a
Residual	12	41,328.1	1.78
P x D	5	9,566.6	< 1
A x P x D	15	20,457.8	< 1
Error (w)			
Error 1 (tests P, AxP)	28	125,616.6	
Error 2 (tests D, AxD)	140	23,254.1	
Error 3 (tests PxD, AxPxD)	140	22,171.2	

^a $p < 0.05$

^b $p < 0.025$

^c $p < 0.001$

to the many perfect scores for the 10 year old group after the first day of learning. Because of the many identical scores it was not possible to make the variance sufficiently homogeneous by transformation. Therefore a probability level of .025 was required as a basis to reject the null hypothesis, rather than the customary .05 level.

A comparison of the performance of the four age groups (Figures 3-6) shows gradual improvement between ages 4 and 8, and then a rapid improvement between ages 8 and 10. This gradual, then rapid improvement, with age between 4 and 10 years is reflected in the significant linear and quadratic components of the term, Age, in Table 1.

The reward problem was significantly more difficult than the nonreward problem (Problem, Table 1). In fact, 26 out of the 32 Ss made more errors on the reward problem. Although the reward problem was more difficult for all age groups, the difference between the difficulty of the two problems decreased with age as the two problems became progressively easier. The significant interaction between Age and Problem is pictured in Figure 7. Four, 6, and 8 year olds responded to the easier nonreward problem with close to 70 percent accuracy and there was little difference between the performance of these age groups on the problem. In contrast, the reward problem was very difficult, and the 4 year olds solved an average of only 37 percent of the reward problems correctly. Between ages 4 and 8 there was a slow improvement but the 8 year olds responded on the average, only at a chance level of accuracy. Ten year olds learned both problems easily and solved an average of 97 percent of the nonreward problems, and 94 percent of the reward problems, correctly.

Learning was measured by improvement in performance over the 6 days, and was demonstrated by the significant linear component of the term, Days,

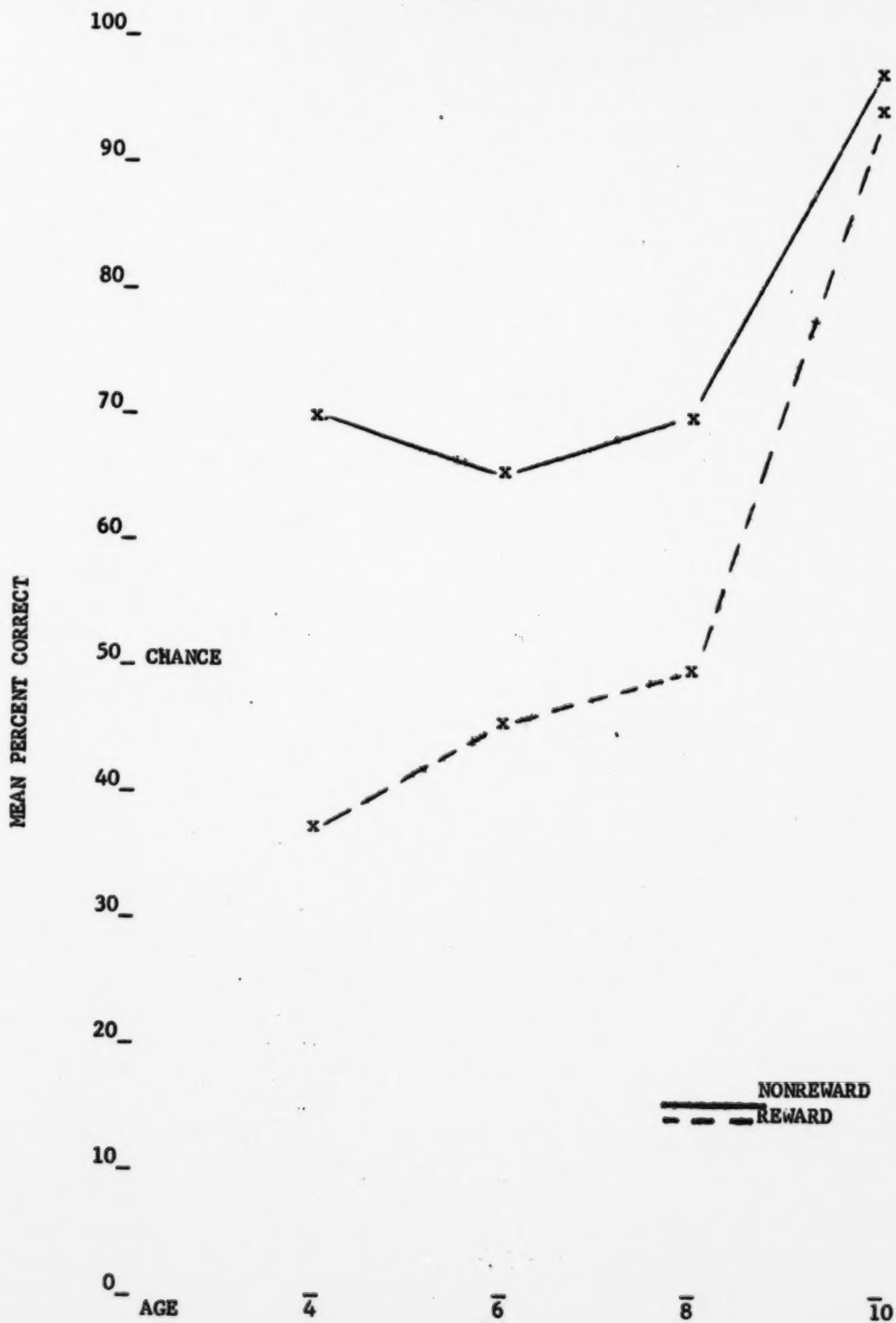


Figure 7. Mean performance of the 4, 6, 8, and 10 year old age groups on the 72 reward problems and the 72 non-reward problems presented.

in Table 1. The differences between extent of learning among the four age groups was tested by the Age x Days interaction. The F value of the linear component of the interaction was 2.67 (df 3/140). The probability of an F value of this size is exactly .05 and therefore the interaction was not considered significant. This indicates that, although overall performance improved with age, there was not a significant difference between age groups in the degree of improvement made between days 1 and 6. However, this analysis does not reflect the very rapid learning of the 10 year old group during day 1. If learning were traced from the initial responses to performance on day 6, it would be apparent that the 10 year olds learned more during the course of the experiment than any other age group. However, much of the learning took place during the trials of the first experimental session. In fact, five of the eight 10 year old Ss made errors only during day 1. In contrast, the 4 year olds, whose initial response tendencies were more correct than those of the older groups', gave no evidence of learning the reward problem during the 6 days, and improved their performance on the easier nonreward problem only after the first four learning sessions.

There was no significant difference between the extent of learning the two problems during the 6 days (Table 1, Problem x Days). Subjects made more errors on the reward problem during the 6 days, but did not improve their performance on one problem more than on another. Age groups did not differ significantly in this respect and the Age x Problem x Days interaction was not significant.

One of the most meaningful findings of this experiment was the rapid learning of the 10 year olds, contrasted with the very gradual increment in the younger groups. On the first few problems the group seemed to have no clearcut strategy in response to the nonreward problem, and their initial

responses to the reward problem could best be characterized as in accord with a win-shift strategy. However, the win-stay, lose-shift strategy was easily available to most of the 10 year old group. Four of the group made less than four errors, two learned later during the first session, and the remaining three children learned during the second or third session. None of the 4 year olds met criterion or verbalized the principle for correct solution of the problem during the six experimental sessions. Of the 6 year old Ss, two children learned to criterion. One S learned on day 4 without being able to verbalize the rule, and another learned to criterion, and was able to verbalize the correct principle, on the sixth day. Three 8 year olds learned during the course of the experiment. One of the 8 year olds who learned on day 1 and another who learned on day 4 were able to verbalize the rule correctly; another who learned on day 5 was not able to state the rule. Of the eight 10 year olds, five were able to verbalize the rule correctly. However, ability to verbalize did not seem to be correlated with speed of solution within this age group. The three 10 year olds who were not able to state the rule all learned with less than four errors. Two of the children, a 6 year old and an 8 year old, stated that the toy was "under the same object", but continued to make response-shift errors on the reward problems.

Since the predominant response tendency was shift, despite reward or nonreward of the object presented on trial 1, the daily performance of the four age groups has been graphed in terms of correct shift minus error shift (Figure 8). Thus, the mean number of reward problems on which the Ss of each group shifted in error was subtracted from the mean number of nonreward problems on which Ss shifted correctly. Random response to reward and nonreward problems by either shift or perseveration is represented by

SHIFT FOLLOWING NONREWARD MINUS SHIFT FOLLOWING REWARD IN PERCENT

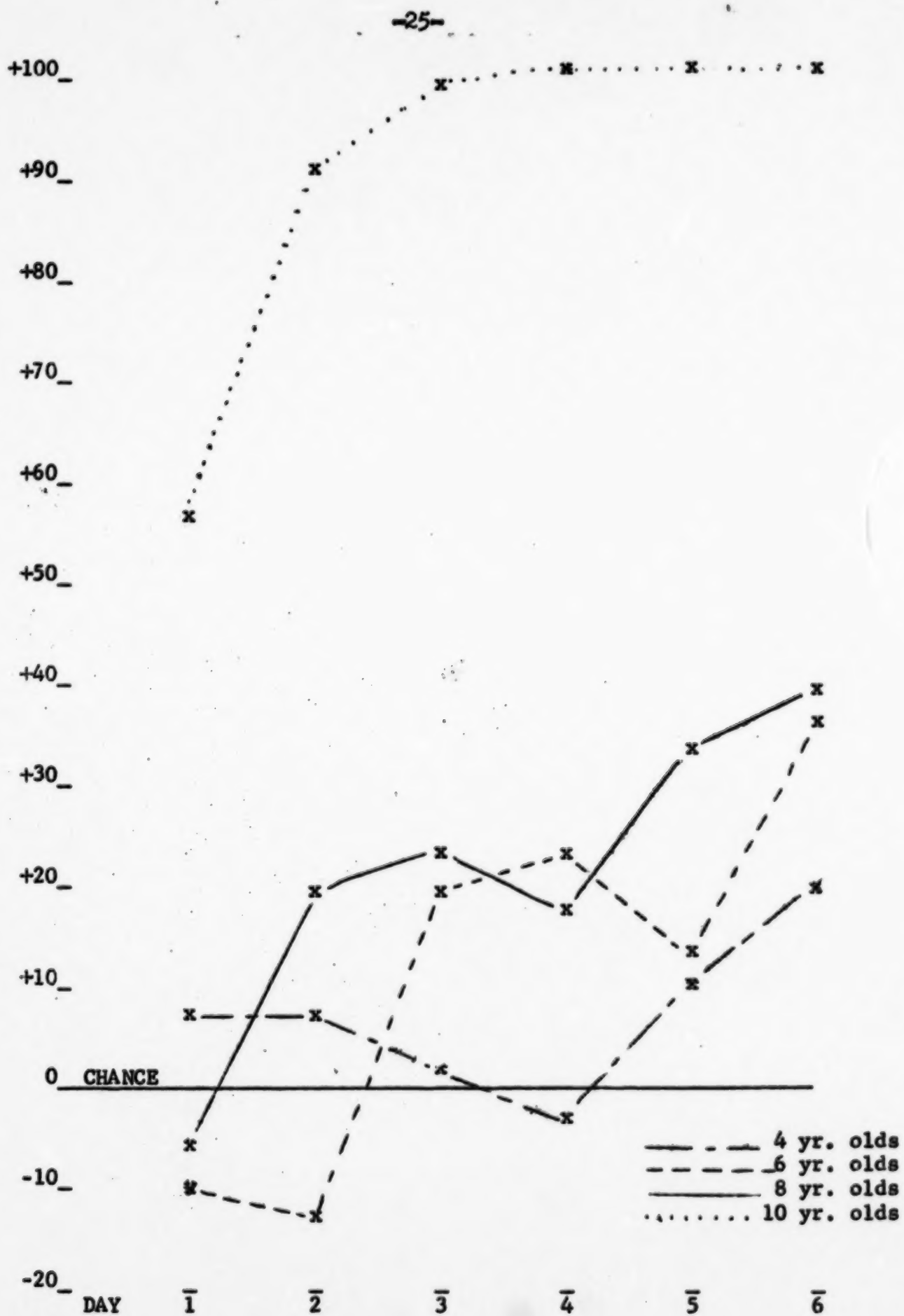


Figure 8. Mean percent correct shift on nonreward problems minus mean percent error shift on reward problems by 4, 6, 8, and 10 year olds on each day.

response at the chance (0 percent) level. If Ss shifted more following reward than following nonreward, performance is represented by a minus value, and if Ss shifted more in response to nonreward problems than reward problems, performance is represented by a plus value.

It had been hypothesized that Ss would make more errors on reward problems following nonreward problems and on nonreward problems following reward problems, than on reward and nonreward problems following the same type problems. This was not a significant effect ($t < 1.0$, $df\ 36$). The effect was tested using problems 2 to 24 of the 6 days of learning for the 19 nonlearners.

Experiment 2: Procedure

Subjects

The Ss were 32 children drawn from the same sources as the Ss in Experiment 1. Half of the children were from 4 to 5 years old and half, from 8 to 9 years old. Two 4 year olds failed to complete the procedures of the experiment and they were replaced by other Ss; one was absent from school after three experimental sessions, and another was reluctant to participate after one session. Sixteen boys and 16 girls were randomly distributed among the two age groups and two experimental groups. The mean ages of the two age groups with 75 percent reward problems were 54.6 months and 100.6 months. The mean ages of the groups with 25 percent reward problems were 52.6 and 100.4 months respectively.

Apparatus and stimuli

The same apparatus and stimuli were used as in Experiment 1.

Procedure

The procedure was the same as that used in Experiment 1 with the following exceptions: Half of the 4 year olds and half of the 8 year olds (Groups 75)

were given 18 reward problems and 6 nonreward problems per day. The remaining half of each age group (Groups 25) were presented with 6 reward problems and 18 nonreward problems per day. Thus, the four groups were Group 75 - 4 year olds, Group 75 - 8 year olds, Group 25 - 4 year olds, and Group 25 - 8 year olds. Twenty-four problems were presented per day for 6 days or until a criterion of correct responses to 10 consecutive problems of the more frequent type and 9 consecutive problems of the less frequent type. The probability of meeting each criterion by chance is .05 (Grant, 1947). The presentation order of reward and nonreward problems was randomly determined with the restrictions that the less frequent problem should occur at least once in every six consecutive problems, but never more than twice in succession.

Experiment II: Analyses of the data and findings

Figures 9, 10, 11, and 12 show the percent of reward and nonreward problems solved correctly on each day by each of the groups. Table II presents a summary of an analysis of the variance associated with these data.

Groups 75 and 25 did not perform significantly differently from each other when scores for the reward and nonreward problems were combined (Experience, Table II) but there was a difference in the performance of the groups on the two problems. As expected, the performance on the reward and nonreward problems reflected the differential amounts of experience of the experimental groups with the two problems. Group 75 solved a greater proportion of the reward problems correctly than Group 25, and Group 25 performed better than Group 75 on the nonreward problem. This was reflected by the highly significant interaction, Experience x Problem (Table II). When data from the four groups were combined the reward problem was significantly more difficult than the nonreward problem (Problem, Table II). It can be seen from Figures 9, 10, 11, and 12 that both age groups having more

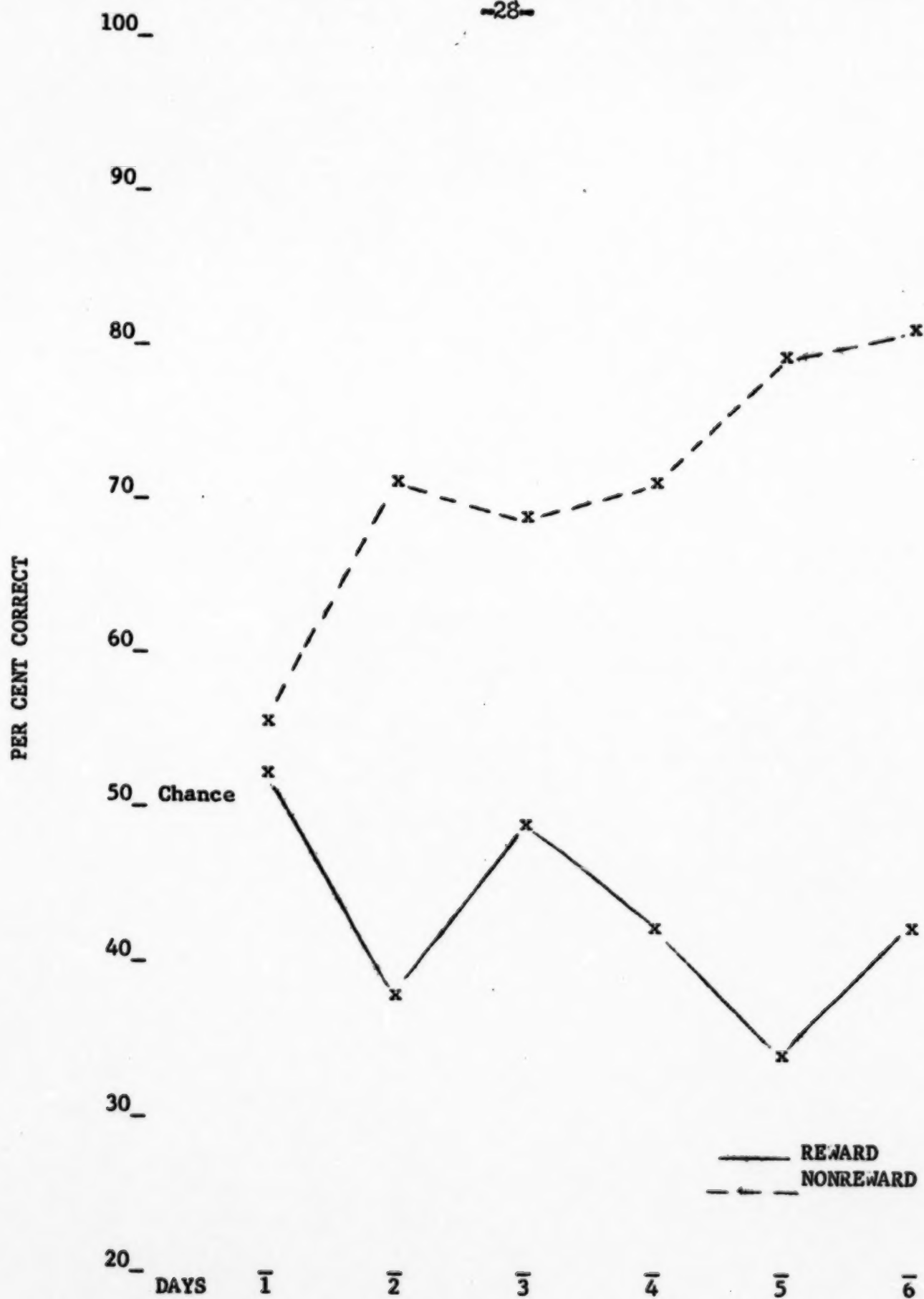


FIGURE 9. Trial 2 performance of 4 year old subjects of group 25 following Trial 1 reward and nonreward. Each subject was given 6 reward and 18 nonreward problems per day.

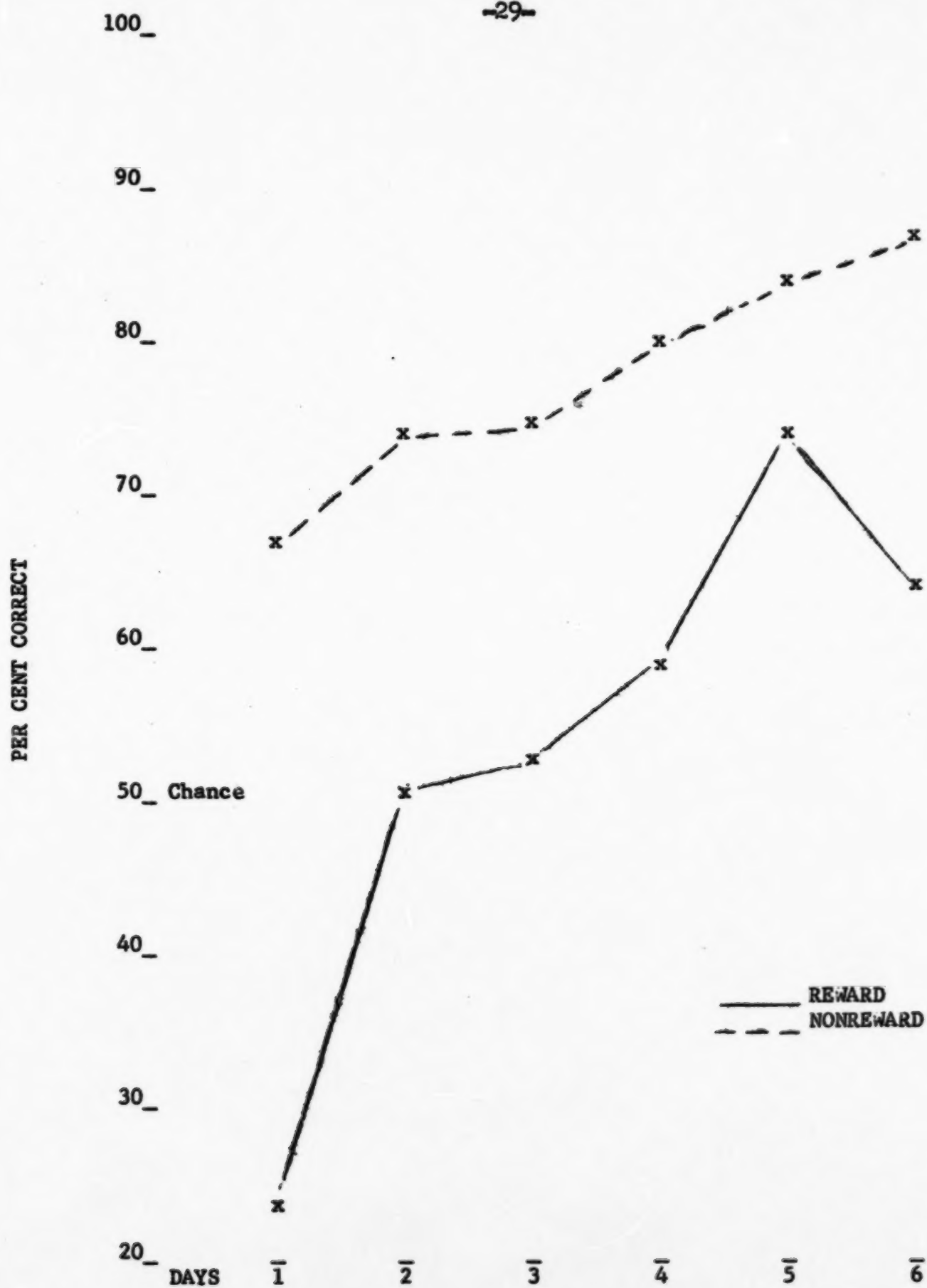


FIGURE 10. Trial 2 performance of 8 year old subjects of group 25 following Trial 1 reward and nonreward. Each subject was given 6 reward and 18 nonreward problems per day.

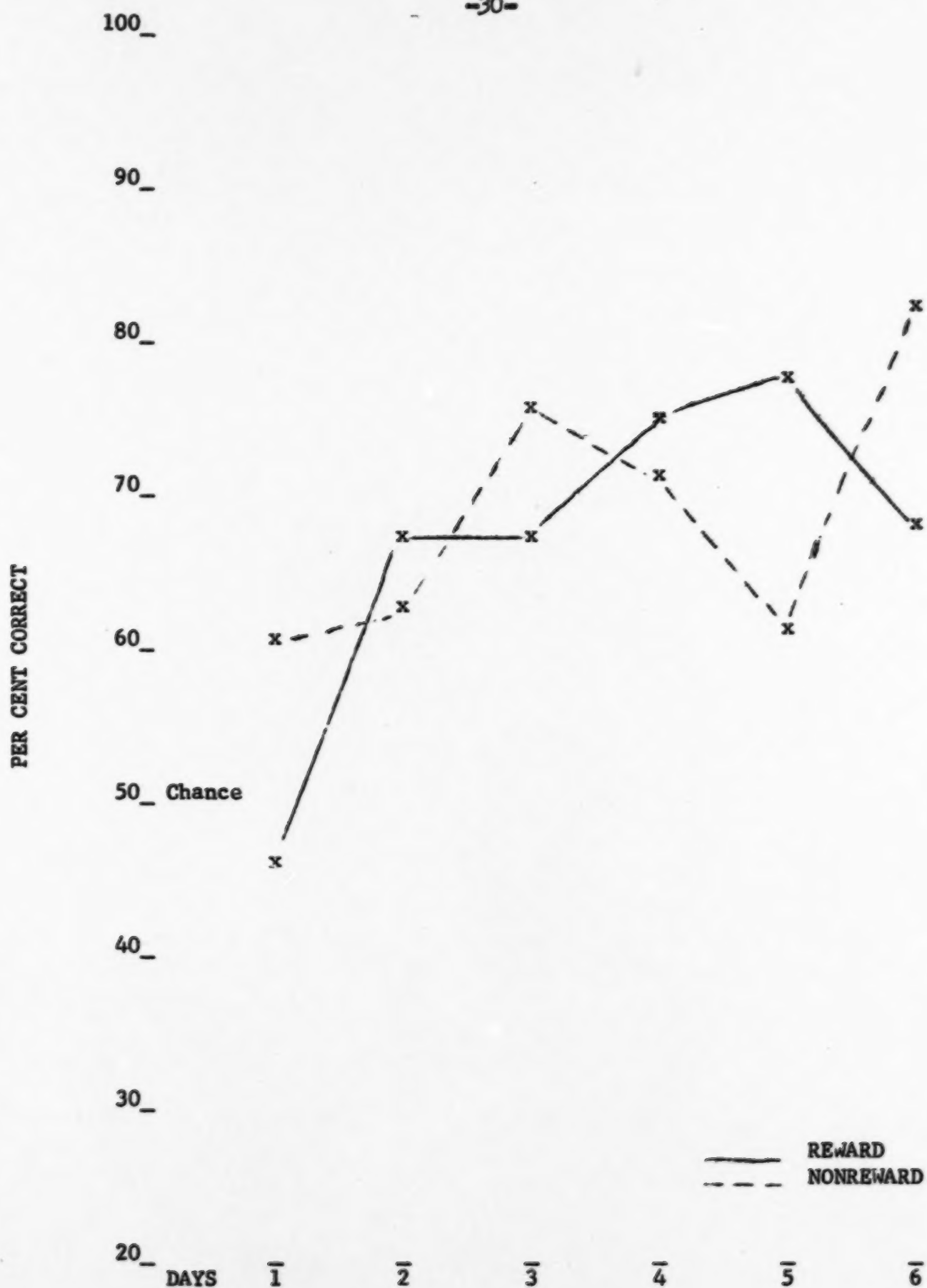


FIGURE 11. Trial 2 performance of 4 year old subjects of group 75 following Trial 1 reward and nonreward. Each subject was given 18 reward and 6 nonreward problems per day.

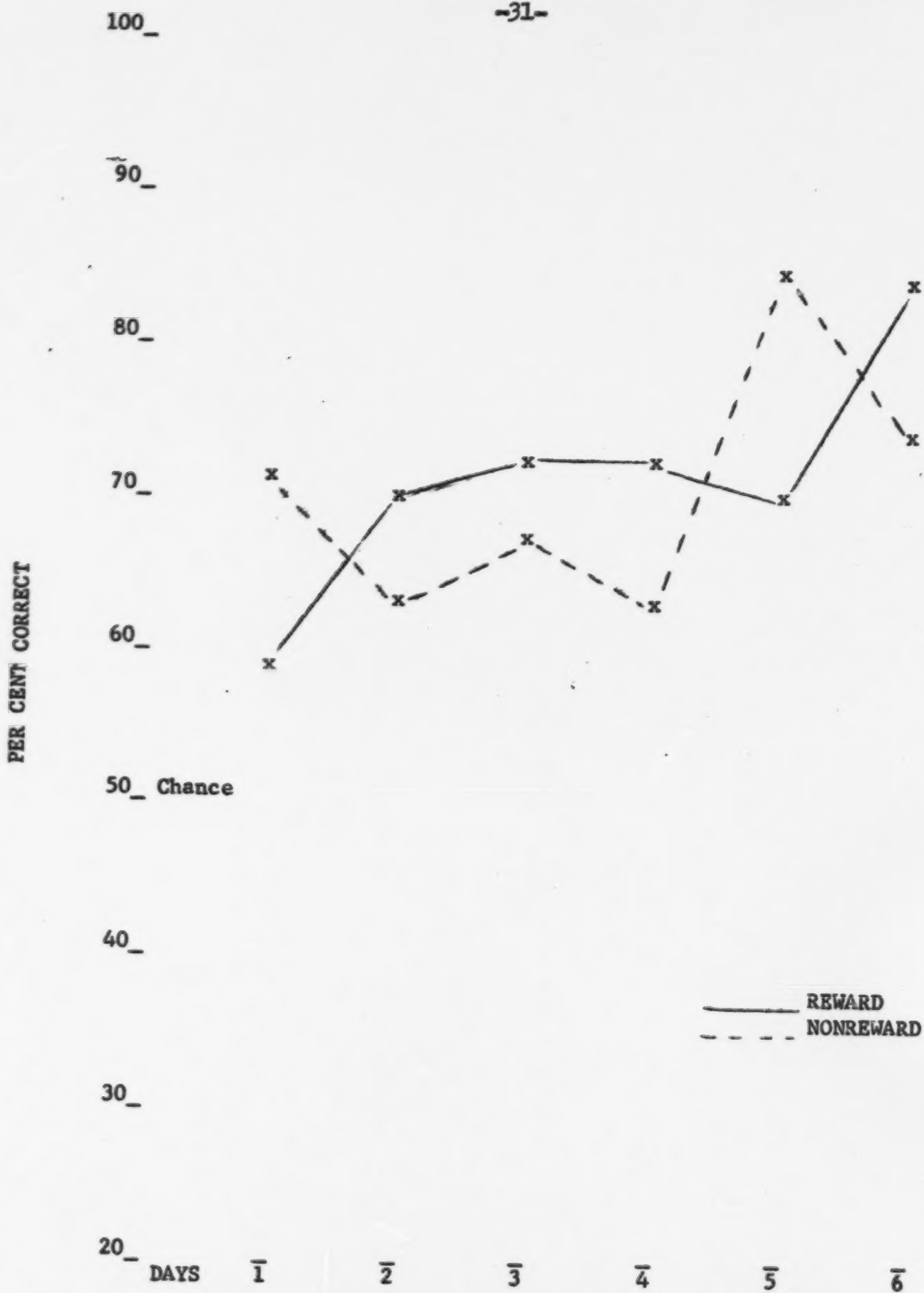


FIGURE 12. Trial 2 performance of 8 year old subjects of group 75 following Trial 1 reward and nonreward. Each subject was given 18 reward and 6 nonreward problems per day.

-32-
Table 2

Analysis of Variance of Learning Scores for Reward and Nonreward
Problems with Two Degrees of Experience with Reward

<u>Source</u>	<u>df</u>	<u>MS</u>	<u>F</u>
Between Ss			
Age (A)	1	302,906.9	1.395
Experience (E)	1	594,169.4	2.737
A x E	1	73,953.1	< 1
Error (b)	28	217,085.5	
Within Ss			
Problem (P)	1	1,745,417.5	10.419 ^c
Days (D)			
Linear	1	1,203,661.9	30.984 ^d
Residual	4	21,870.1	< 1
A x P	1	35,209.0	< 1
A x D			
Linear	1	109,168.2	2.810
Residual	4	26,124.4	< 1
E x P	1	1,555,121.5	9.283 ^c
E x D			
Linear	1	5,808.1	< 1
Residual	4	3,922.0	< 1
P x D			
Linear	1	348.3	< 1
Residual	4	23,923.5	< 1
A x E x P	1	2,041.2	< 1
A x E x D			
Linear	1	200,933.0	5.172 ^a
Residual	4	42,717.5	1.100

-33-
Table 2
(Continued)

<u>Source</u>	<u>df</u>	<u>MS</u>	<u>F</u>
E x P x D			
Linear	1	51,050.2	1.664
Residual	4	26,751.9	< 1
A x P x D			
Linear	1	188,135.9	6.132 ^a
Residual	4	29,459.3	< 1
A x E x P x D			
Linear	1	185,526.7	6.044 ^a
Residual	4	117,746.4	3.838 ^b
Error (W)			
Error 1 (tests P, AxP, ExP, AxExP)	28	167,524.2	
Error 2 (tests D, AxD, ExD, AxExD)	140	38,847.6	
Error 3 (tests Px D, ExPx D, AxPx D, AxExPx D)	140	30,680.0	
Total	383		

^a $p < 0.025$

^b $p < 0.01$

^c $p < 0.005$

^d $p < 0.001$

experience with the nonreward problem (Groups 25, 4 and 8 years) performed considerably better on the nonreward problem than on the reward problem. However, there was little difference between the performance on the reward and nonreward problems of the groups which had greater experience with the reward problem. Both the 4 and 8 year olds required three times as much experience with the reward problem to perform at the same level of accuracy as on the nonreward problem.

Eight year olds did not perform, on the whole, significantly better than 4 year olds (Age, Table II). There were no significant differences between the performance of the two age groups on the two problems (Age x Problem, Table II), or on the overall performance of groups 75 and 25 (Age x Experience, Table II). The effects of differential experience with reward and nonreward on the learning of the two problems did not differ for the two age groups (Age x Experience x Problem, Table II).

The significance of the linear component of the term, Days, (Table II) demonstrates that learning did occur during the six days of experimental sessions. Although there was a highly significant difference between the Ss' performance on the reward and nonreward problems there was no significant difference between the extent of learning the two problems (Problem x Days). Groups 75 and 25 did not differ significantly in the extent of overall learning (Experience x Days) or in extent of learning on the two problems (Experience x Problems x Days).

Although 8 year olds did not learn more, on the whole, than 4 year olds (Age x Days, Table II) there were some interesting effects of age on learning. When scores on both problems were taken into account there was little difference between the performance of the 4 year olds in Groups 75 and 25 on the initial day of learning. However, during the six sessions, the

4 year olds in Group 25 learned little compared with those in Group 75. In contrast, the 8 year olds of Group 25 performed at a lower level than any other group on day 1, but learned more than any other group during the 6 days. Although the Group 75 8 year olds performed at the highest level of accuracy by the last day of the experiment their performance was at a relatively high level on the first day, and they learned less than the 8 year olds in Group 25 between days 1 and 6. The differential effect of age on the extent of learning of the experimental groups 75 and 25 was significant (Age x Experience x Days, Table II).

There was also a significant linear component of the interaction, Age x Problem x Days (Table II). Eight year olds showed more error-shift than 4 year olds during the first learning session, but they made fewer and fewer errors during the course of the experiment, and they learned more in response to the reward problem than the nonreward problem. Four year olds, on the other hand, learned little on the reward problem during the 6 days and their responses to this problem remained close to the chance level. They learned somewhat more than the 8 year olds, though, on the easier nonreward problem, performing at a lower level initially and finally performing at approximately the same level as the 8 year olds.

There was an additional significant interaction (Age x Experience x Problem x Days, Table II). It appeared to be due mainly to differences between the age groups in Group 25 in extent of learning the reward problem. The 4 year olds of Group 25 did not improve their performance on the reward problem during the course of the experiment, while the 8 year olds of this group improved their performance on this problem greatly after an initially poor performance on day 1. In short, the 8 year olds, who initially performed more poorly than the 4 year olds, were able to learn to suppress

their response-shift tendencies, given minimal experience, while the 4 year olds were not able to learn under these conditions.

Experiment 3: Procedure

Subjects

The Ss were 64 children drawn from the same sources as the Ss in Experiments 1 and 2. Sixteen of the children were between 4 and 5 years old, 16 were between 6 and 7 years old, 16, between 8 and 9, and 16, between age 10 and 11. Two 4 year olds were unable to complete the experimental procedures and were replaced by other Ss: one child was absent from school for several days following one learning session, and the other refused to participate after one session. One 8 year old was not used as a S because of reported brain damage. He was replaced by another S. Half of the children in each age group were given Procedure A and the others were given Procedure B. The four age groups to whom Procedure A was administered had mean ages of 53 months, 81 months, 101 months, and 124 months. Those with Procedure B had mean ages of 55 months, 79 months, 100 months, and 127 months. The 34 girls and 30 boys taking part in the experiment were distributed randomly among the four age groups and two experimental groups.

Apparatus and stimuli

Apparatus and stimuli were the same as that used in Experiments 1 and 2.

Procedure

The procedure was the same as that used in Experiment 1 with the following exceptions: No nonreward problems were given. The Ss were tested with 108 reward problems (24 problems per day for 4 days and 12 problems on the 5th day) or until a criterion was met of correct responses to 10 consecutive problems. Half of the Ss in each age group were given Procedure A, the

same procedure as used for presentation of reward problems in Experiments 1 and 2. The remaining half of the Ss in each age group were given Procedure B, with two baited objects presented on the first trial of each problem. The first trial stimuli were presented covering the two side wells. Choice of either object was rewarded. On trial 2 both of the trial-1 stimuli were again presented, but only the stimulus chosen on trial 1 was baited.

There were, thus, eight groups of Ss with eight Ss each: 4, 6, 8, and 10 year olds with Procedure A, and 4, 6, 8, and 10 year olds with Procedure B.

Experiment 3: analyses of the data and findings

Procedure A versus B

Figure 13 presents mean learning scores for each of the eight groups in percent correct problem solutions. Of the 64 Ss, 33 met criterion during the first learning session and many learned with very few errors. The data were therefore analyzed in terms of percent correct responses to the total 108 problems, rather than in percent correct per day. An arc sin transformation was used to transform the data to reduce heterogeneity of variance due to the many nearly perfect scores in some groups, and an analysis of variance was computed.

Figure 13 shows that the Ss with Procedure A learned with fewer errors than the Ss with Procedure B. The difference was significant at the .05 level of confidence ($F = 4.524$, $df\ 1/56$). Generally errors decreased with age ($F = 4.717$, $df\ 3/56$, $p < .01$). Although 4, 8, and 10 year olds with Procedure B made more errors than Ss of the same age with Procedure A, the 6 year olds with Procedure B performed better than the same age group with Procedure A. The interaction between Age and Procedure

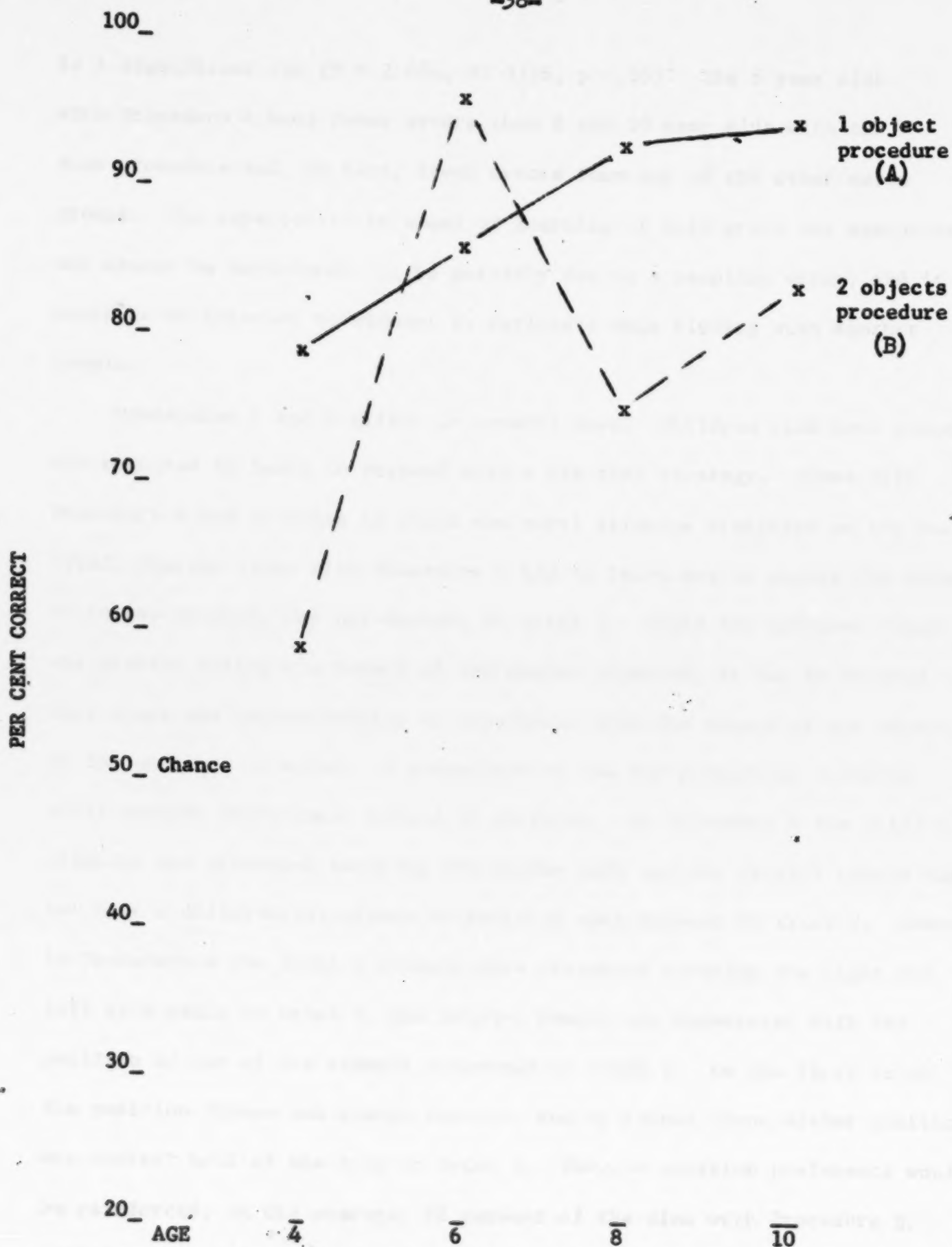


FIGURE 13. Trial 2 performance of 4, 6, 8, and 10 year old subjects following either a 1 object or 2 object procedure on Trial 1. Each subject was rewarded for all Trial 1 choices.

is a significant one ($F = 2.844$, $df\ 3/56$, $p < .05$). The 6 year olds with Procedure A made fewer errors than 8 and 10 year olds with the same procedure and, in fact, fewer errors than any of the other seven groups. The superiority in speed of learning of this group was unexpected and cannot be explained. It is possibly due to a sampling error, and it would be of interest to attempt to replicate this finding with another sample.

Procedures A and B differ in several ways. Children with both procedures are required to learn to respond with a win-stay strategy. Those with Procedure A had to learn to avoid the novel stimulus presented on the second trial, whereas those with Procedure B had to learn not to choose the stimulus which was present, but not chosen, on trial 1. Since the unchosen object was present during the reward of the chosen stimulus, it can be assumed that there was generalization of excitation from the reward of the chosen to the unchosen stimulus. A comparison of the two procedures involves still another difference, reward of position. In Procedure A the trial-1 stimulus was presented covering the middle well and the trial-1 reward did not have a differential effect on position cues present on trial-2. However, in Procedure B the trial-1 stimuli were presented covering the right and left side wells on trial 1, and trial-1 reward was associated with the position of one of the stimuli presented on trial 2. On the first trial the position chosen was always correct, and by chance alone either position was correct half of the time on trial 2. Thus, a position preference would be reinforced, on the average, 75 percent of the time with Procedure B. With Procedure A position preferences would be reinforced only on trial 2, and then only 50 percent of the time.

An analysis of trial-2 responses made prior to criterion by Ss with Procedure B showed that, in fact, many were part of long runs of perseverative responses to position. Position perseverations were defined as runs of eight or more consecutive responses on any one day to the same position as the previous response. The probability of a run of such a length in 24 trials is less than .05. The 5th session, when only 12 problems were given, and the day on which S met criterion, were not included in this analysis. The groups with both procedures were compared for frequency of perseverative responses on days when they had equal opportunity to make the responses.

In Group B the 18 Ss who did not learn on day 1 had an opportunity to persevereate position choice on 23 of the 24 problems per day for a total of 52 days before they met criterion. Therefore, it was possible for the responses to 1196 problems to have been part of position runs. Twenty-one perseverative position runs, which included 297 responses, were made by 10 of the 18 children from Group B who failed to learn on day 1. Thus 24.8 percent of the precriterion responses, on which Ss had full opportunity to make perseverative responses, were part of position runs. Most of the perseverations were made by six 4 year olds.

In contrast, only one S from Group A, a 6 year old, made a run of eight perseverative position responses. Only 1.2 percent of the 644 precriterion responses were part of perseverative position runs. A comparison between the two groups by Chi Square showed a significant difference between the frequency of responses which were part of perseverative runs in proportion to the number of problems on which there was full opportunity to make such responses (Chi Square, 166.8, df 1, $p < .01$).

Because of the difference with the two procedures in frequency of position runs during learning of the reward problem, it is reasonable to assume that at least some of the greater difficulty of Procedure B is due to the greater opportunity for the reinforcement of position preferences. It is not known how much of the difficulty with Procedure B was associated with reinforcement of position preferences, and how much was due to the effects of generalization of reward from the stimulus chosen on trial 1 to the unchosen stimulus.

Groups 100-A versus Group 75

Both Group 75 (from Experiment 2) and Group A (Experiment 3) were given 108 reward problems. The problems were administered with the same procedure but Group 75 was given 36 additional nonreward problems. A comparison was made between the performance of the two groups on the reward problem and it was hypothesized that Group 75 would make more errors on the reward problem because of interfering effects from reinforcement of response-shift tendencies in response to the nonreward problems.

The 4 year olds and 8 year olds of Group 75 solved a mean of 66.2 and 70.5 percent of the reward problems correctly, respectively. In contrast, the 4 year olds with reward problems only (Group A) solved an average of 77.4 problems correctly, and the 8 year olds of the same group, a mean of 91.8 problems correctly. The scores, in percent correct solutions of the 108 reward problems, were transformed with an arc sin transformation to reduce heterogeneity of variance due to the many nearly perfect scores of the groups with reward problems only. An analysis of variance confirmed the hypothesis that the children with additional nonreward problems (Groups 75) would make more errors than those with only reward problems ($F = 7.377$, $df\ 1/28$, $p < .05$). The difference between the two age groups

was not significant ($F = 2.142$, $df\ 1/28$), nor was the interaction between age and experimental procedure significant ($F < 1.0$, $df\ 1/28$).

Conclusions

Both response-shift and response-perseveration tendencies appear to be important sources of error in children's discrimination learning. Comparisons were made between the strength of the two error tendencies during the ages 4 to 10 years, using a learning-set procedure with many two-trial problems and multidimensional stimuli which were changed on each problem. The Ss were required to respond according to a win-stay, lose-shift principle. The effects of experience with reward and nonreward problems, and the effects of novelty and of generalization of excitation from reward, were tested.

The results were as follows:

Experiment 1

A comparison was made between the performance of 4, 6, 8, and 10 year olds, each given 72 reward and 72 nonreward problems.

1. Age was a significant variable; there was a gradual improvement between ages 4 and 8 years, and a rapid improvement between ages 8 and 10.

2. On the first few problems none of the age groups tested tended to repeat a choice following reward. More older children than 4 year olds tended to shift choice after reward. Ten year olds learned to suppress response-shift error tendencies rapidly during the first learning session, and many of them learned both the reward and nonreward problem with few errors. Although the 10 year olds responded initially with a win-shift strategy,

and without a clearcut strategy for the nonreward problem, the win-stay, lose-shift strategy seemed to be readily available to them. The 4 year olds, on the other hand, showed slow improvement on the easier nonreward problem and no improvement on the more difficult reward problem during the 6 days of the experiment. Although some of the 8 and 10 year olds verbalized the principle for problem solution, the ability to verbalize the "rule" was not necessarily associated with rapid solution of the problems.

3. The reward problem was significantly more difficult than the nonreward problem.

4. Younger children showed more of a difference between performance on the reward and nonreward problems than older children. With age there was a significantly greater decrease in the number of response-shift errors on the reward problem than in the number of response-perseveration errors on the nonreward problem, and the 10 year olds made only slightly more errors on the reward than on the nonreward problem.

5. There was no significant difference between the extent of learning on the reward and nonreward problems during the 6 days of the experiment.

6. There were not significantly more errors on problems which followed different type problems (reward problems following nonreward problems, and nonreward problems following reward problems) than on those problems which followed same type problems (reward problems following reward problems and nonreward problems following nonreward problems).

Experiment 2

Four and 8 year old Ss were divided into two groups; half were given 108 reward problems and 36 nonreward problems (Group 75), and half were given 36 reward problems and 108 nonreward problems (Group 25).

1. Differences in experience with the two problems had a significant effect such that those Ss with more experience with the reward problem (Group 75) made fewer response-shift errors on the reward problem than Ss with less experience with the reward problem (Group 25). Group 25, which had more experience with the nonreward problem made fewer response-perseveration errors on the nonreward problem than Group 75.

2. When data from both groups were combined the reward problem was significantly more difficult than the nonreward problem.

3. Both age groups given three times as much experience with the reward problem as with the nonreward problem (Group 75) performed at approximately the same level of accuracy on the two problems. Those with three times as much experience with the nonreward problem (Group 25) performed better on the nonreward problem.

4. When overall accuracy was considered 8 year olds did not perform significantly better than 4 year olds. There were no differential effects of age on the performance of the two problems, and age did not interact significantly with amount of experience on the two problems.

5. The following effects of age were significant: 4 year olds learned little on the difficult reward problem compared with

8 year olds who made more response-shift errors during the initial learning session, but learned to suppress these error tendencies during the 6 sessions. The 4 year olds learned more on the easier nonreward problem though, than the 8 year olds, performing at a lower level initially, but by the end of the 6 days, performing at approximately the same level of accuracy as the 8 year olds.

Four year olds from Group 25 learned little compared with 4 year olds from Group 75. In contrast, the 8 year olds of Group 25 learned more than the 8 year olds of Group 75. There was an additional significant effect of age on the differential learning of the two problems by the two groups; 4 year olds with little experience on the reward problem (Group 25) did not show any learning on the reward problem during the 6 days. In fact, their performance deteriorated slightly. Eight year olds of Group 25, on the other hand, performed very poorly on the reward problem on day 1, but learned more during the 6 days than any other group, with any problem. The major difference between the two age groups appeared to be that 8 year olds were able to learn and improve their performance during the course of the experiment, given the more difficult problem and minimal experience, while 4 year olds were not able to do so even though they made fewer errors initially than the 8 year olds.

Experiment 3

Four, 6, 8, and 10 year olds were each given 108 reward problems and no nonreward problems. Half of the Ss in each age group were given the reward problem with the same procedure as in the preceeding experiments (Procedure A). That is, one stimulus

was presented in the center position and rewarded on trial 1. On trial 2 it was again presented, paired with a new stimulus. The trial-2 stimuli were presented in the right and left positions and choice of the same stimulus was again rewarded. The remaining half of the Ss were given Procedure B. Two stimuli were presented in the side positions, and choice of either stimulus was rewarded. Both stimuli were again presented on trial 2 and choice of the same stimulus chosen on trial 1 was rewarded.

1. Procedure A was significantly easier than Procedure B. The difference between the difficulty of the two procedures may have been due to the additional opportunity with Procedure B for reinforcement of position preferences. A significantly greater proportion of precriterion responses of Group B than of Group A were part of position perseveration runs.

2. In general, older children made significantly fewer errors than younger children, although there was a significant interaction between age and procedure caused by the unexpectedly superior performance of the 6 year olds of Group B, who made fewer errors than any other group.

3. The performance of the 4 and 8 year old Ss in Group A was compared with the performance of Ss of the same age of Group 75 (Experiment 2) on the reward problem only. Both groups were given 108 reward problems with the same procedure, but Group 75 was given an additional 36 nonreward problems. It had been hypothesized that Group 75 would perform significantly more poorly than the group given reward problems alone, because during the learning of the nonreward problem Group 75 would experience reward of response-shift tendencies and these tendencies would interfere with the learning of the reward problem. The hypothesis was confirmed.

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